

## UNIT 5 - RENEWABLES

### SECTION 2 - HYDROPOWER



Investigation



# WAVES AND WHISTLES

ADAPTED FROM:

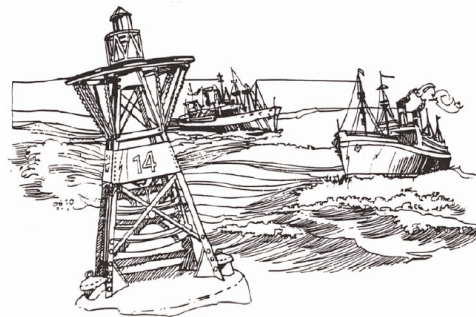
GEORGE HAGERMAN, "WAVES AND WHISTLES," 1991

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## Background Information

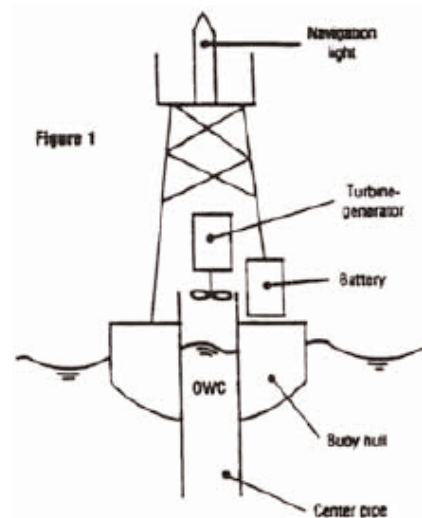
Fossil fuels such as coal and oil are not renewable over the span of human generations, and their use may be increasingly limited by environmental concerns over global warming and acid rain. To meet the energy needs of a growing world population, engineers in coming decades will be challenged to economically generate power from solar energy sources.

Ocean waves are a tertiary form of solar energy, in that unequal heating of the Earth's surface generates wind, and wind blowing over water generates waves. Despite the fact that nearly 75% of the Earth's surface is covered with water, waves are a largely unexplored source of energy compared with the progress that has been made in harnessing the sun and wind.



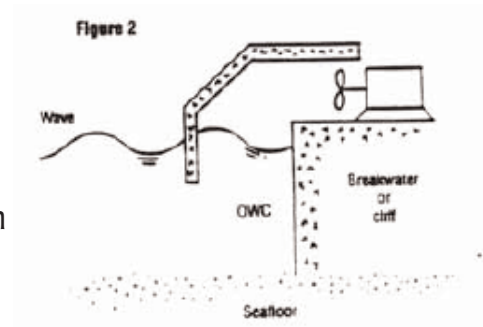
Commercial use of wave power is now limited to small systems of tens to hundreds of watts such as navigation buoys. Oscillating water columns (OWC) use the rolling motion of the waves to compress air that drives a turbine and a generator. A hollow cylinder or shaft is built underwater. Waves cause the water in the column to rise and fall, alternately pushing air out the top of the column and drawing it back in.

Buoys, which heave up and down in waves, can use the OWC technology. The center pipe of the buoy's hull acts like a piston, pushing air out the top of the pipe and drawing it in. This pneumatic power can be converted directly to sound through a foghorn, or indirectly to light by spinning a turbine-generator, which charges an electrical storage battery (Figure 1).



## WAVES AND WHISTLES INVESTIGATION CONT.

Ocean-wave energy conversion for utility-scale power generation is not yet a commercial technology, but shore-based demonstration plants using the OWC process described above have operated in Japan, Norway, and the United Kingdom (Figure 2). The output of these plants is much larger, however, ranging from tens to hundreds of kilowatts.



In this activity you will build an OWC, demonstrate the energy transformations that take place in converting wave motion and force into useful work, and devise a more efficient way to direct air through a turbine.

**Problem** *(fill in problem):* \_\_\_\_\_

**Hypothesis:** If \_\_\_\_\_

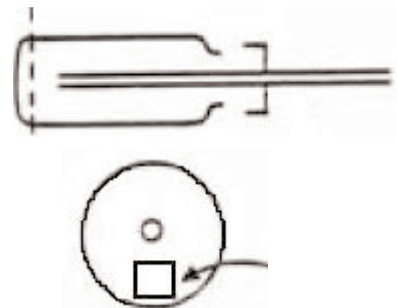
## Materials

1 five-gallon bucket  
water  
plastic water bottle with screw cap  
large drinking straw (about the size of a tennis ball can)  
turbine wheel whistle (often used as a party favor)  
utility knife  
6 strips of tape 1.5" x 3/4"



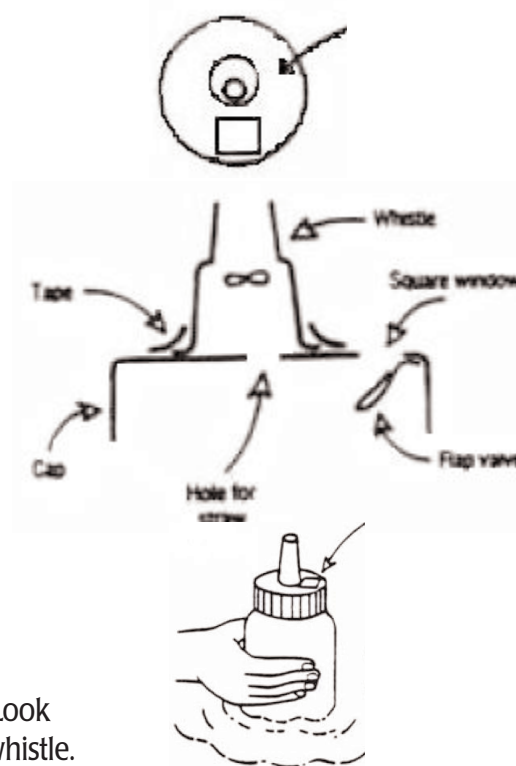
## Procedure

1. Cut the bottom off the water bottle.
2. Remove the straw and cut a hole, approximately 1/2-inch square, next to the edge of the cap.



## WAVES AND WHISTLES INVESTIGATION CONT.

3. Use four strips of tape to mount the whistle over the drinking straw hole.
4. Make a one-way "flap valve" by folding a strip of tape back on itself such that only 1/4 to 3/8-inch of adhesive surface is exposed, and tape this adhesive surface to the underside of the bottle cap, right next to the edge of the cap.
5. Test the model in a sink or bucket of water to make sure that there isn't excessive water leakage around the taped edges.
6. Tape the top of the cap over the flap valve window.
7. Fill the bucket to within 2-3" from the top with water.
8. Move the bottomless bottle up and down in the water. Look down into the whistle and observe the blades inside the whistle.
9. Remove the strip of tape that was covering the flap valve window.
10. Repeat step #8



## Observations

1. Explain the motion of the blades when the flap valve was closed. \_\_\_\_\_  
\_\_\_\_\_
2. Explain the motion of the blades when the flap valve was open. \_\_\_\_\_  
\_\_\_\_\_
3. What are the energy transformations in an OWC? \_\_\_\_\_  
\_\_\_\_\_

## WAVES AND WHISTLES INVESTIGATION CONT.

### Conclusion

1. What are the negative consequences on the turbine blades when the flap valve is closed?

\_\_\_\_\_

2. A gear mechanism would solve the problems caused from the blades' reversing direction. Explain why a gear mechanism may not be the best solution. \_\_\_\_\_

\_\_\_\_\_

3. What are the advantages of a one-way flap valve? \_\_\_\_\_

\_\_\_\_\_

4. How could you improve on this OWC model? \_\_\_\_\_

\_\_\_\_\_

### Application

1. Flywheel inertia of the turbine keeps it spinning while air is being drawn in through the flap valve. How could you improve the efficiency by direct air through the turbine on both the up and down stroke? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_